Notes for the liquid scintillator detector including specifications for the proposal's baseline costing

Jeff Nelson
2/12/04

This is based on notes from the February 2004 OA meeting and construction workshop held at Fermilab.

1. Design outline/assumptions

Extrusions

- The modules have PVC extrusions that come cut to length by the vendor with flat ends.
- They are shipped with wrapping on the ends to keep stuff from flying or crawling into the tubes between extrusion and arrival into the factory.
- They come banded in groups of 24 on some sort of wood shipping packaging that can be stacked and can be forked from two points and craned with a spreader. They are reused for shipping completed modules and recycled for future shipments. The shipping packages can be staked 4 high. We provide the packaging.
- The extrusions are not light tight through the sides.
- Trucking of the extrusions to the factories is part of the quoted contract. ???

Fiber

- Fiber comes from Kurray on spools of 10km.

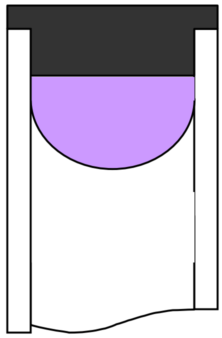
Factory assumptions (some from Gina and some from Jeff)

- 2 factories. One in the greater Chicago area (C) and one in Minnesota (M)
- Sites are mostly empty at the time of the possession and the labor is for outfitting for the factory machines and stations.
- Oversight by free physicists, free clerical labor.
- Each factory runs one shift.

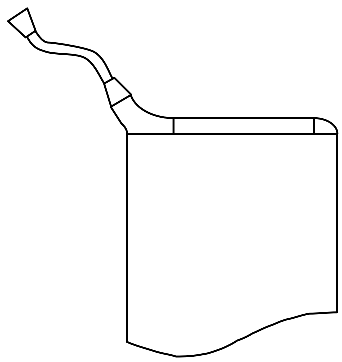
- C has
    - High bay with loading dock
    - Bridge crane
    - Basic rigging gear (slings, spreaders…)
    - Laboratory labor rates (SWF and indirect)
    - Machine shop and reasonable supply of small tools

- M has
  - Empty warehouse space (provided by the institution)
  - 50/50 mix of students and civil technicians
  - Will need to either install a wheeled gantry or electric fork (used)
  - Loads may get bulled around by two electric pallet jacks

- Fiber
  - Fiber comes in small diameter spools in large wood shipping crates from Kurrary FOB the factories. A pallet jack can move these boxes. There are 2 (?) kilometers on a spool. That's a little more than 2 modules worth.



- Endcaps
  - These parts are injection molded. (???) Could be extruded and the ends machined.
  - Made from dark PVC
  - Assume that the seals are inset into the foot of the extrusion so they fit flush in the stacks.



- Parts for the readout end of the module (AKA manifold)
  - Unlike in the current proposal draft and the PowerPoint that people used the OA modules have something like MINOS straight-out snout. Instead of ending in a connector, though, they end in a flexible conduit (or snorkel) that is optical conduit with a cookie on the end. Within the end seals the fibers are loose. All of these components have labyrinth seals to keep out light and to provide ample surface for reliable leak-proof sealing the joints.
  - Corner seal
    - There is a rounded corner that is like the MINOS seal.
    - It is black injection molded PVC.
  - Readout end seal
    - A long seal on the ends of the modules is extruded black PVC.
    - It contains the readout fibers but they are loose.
    - The black PVC may be enough to ensure that light from particles entering the fibers since it usually has to bounce multiple times. If tests show this doesn't work then we may need to add in two layers of black poly sheets around the fibers to isolate them from the bulk of the liquid.
  - Snout seal
    - This routes the fibers from the end seal to the clamshells.
    - It looks like part of a straight out manifold for a MINOS module.
    - It is injection molded black PVC.

- Clamshells
    - These are two identical parts that go round the fibers. They mate up with the snout seal and the optical conduit (snorkel).
    - They are black injection molded parts.
- Conduit
    - This is the same black flexible plastic tubing used by MINOS and D0. A length of 0.6m is used for each module.
- More clamshells
    - These mate to the conduit to the cookie. They are probably different parts than those used for the snout seal.
- Cookie/Connector
    - These look very similar to the MINOS optical connectors.
    - They have 4 parallel rows of 30 holes to match up with the APD face.
    - They have threaded holes to mate up with the outside of the APD housing and act as the cookie on the APDs face.
    - They are light tightened with a… ??? How about a black ploy sleeve like the ends of the MINOS modules.
- Light tightening
    - Something needs to be done to light tighten the extrusions. Deep in the stacks we'll be OK but the end meter or two will need something done to it.
        - This is an R&D issue.
        - For the baseline we assume that black poly is slid onto the ends.
        - Hopefully a paint/spary solution will be found.
        - Another option is to put a seal around the ends of the modules on the end of the stacks.

- **Modules assembly steps (Current Baseline)**

- Receiving of materials
    - The extrusions get off loaded from truck & put into buffer using a crane or monorail.
    - The fiber
        - Comes in every month (?) or so.
        - Batch test the spools fiber (as in MINOS) or attenuation length. A modified version of Leon's test machine is needed for each factory.
    - The end pieces, connectors, snorkels…
        - Will come in shipping crates that can be moved by pallet jack.

- Move extrusions to assembly station
    - Moved with rolling tables (like in MINOS) or just slid since they are not too heavy
    - Visual inspection of extrusions

    - Add bar code/serial number; note shipping lot

- Prep foot of module by routing out ends of webs
    - Router had a vacuum to catch the chips
    - Would one need to deburr?

- Insert fibers in extrusion
    - Done in parallel for a number of cells at a time using a machine
    - Record fiber lot number
    - Machine takes up 52' of fiber onto a bobbin
    - Put a mandrel on the loop of the fiber
    - Machine push mandrel through the cell to far end
    - Rough-cut of fiber

- Seal the foot of the module
    - Apply glue to cap
    - Use jig to press cap and hold the fiber in place

- Assemble head of the module
    - Route fibers into snout, snorkel, and connector
    - Glue side seal to cover
    - Glue cover assembly to module/snout

- Glue fibers
    - Inject the glue
    - Let cure
    - Fly cut

- Testing
    - Optical continuity test (flesh and look for light coming back)
    - Pressure leak test
    - Wrap and stow the snorkel for shipping

- Move module in shipping container/file traveler
    - Could do this by hand of with vacuum fixture
    - Package/fixture into shipping packaging
    - Close up packaging and stage for shipping

- Move shipping container to truck and ship to detector site

Factory Labor estimates

- Assume 3 modules produced at a time
  - Receive crates from extruder (2 min; amortized)
  - Lift module from crate into position (3 min)
  - Cut channel in bottom cell walls (5 min)
  - Put fiber in tubes (30 min)
  - Glue bottom (10 min)
  - Route fiber through snout into connector (30 min)
  - Glue manifold (10 min)
  - Pressure test manifold (10 min)
  - Fly cut fibers (15 min)
  - Stack in shipping crate (3 min)
- Rolls 2 FTE-hour/module (Mualem, Pearson, Heller)

Factory Machines/Stations (2X unless noted)

- Shipping packaging (How many?)
- Way to move shipping containers for "M" factory
- Fiber (batch attenuation) tester adapted from Leon's MINOS machine
- Method for sliding extrusions from staged shipping package to workstations
- Stations for working on modules. Could be flat tables or something like the MINOS indexing shelves
- Barcode scanner, bar code printer, barcode stickers
- Router bits, drill body, fixturing for uniform depth/location, vacuum head
- Fixture for jigging in the Endcap for curing
- PVC Glue (volume/vendor/quote)
- Fiber-bobbin winder, fiber pusher (sucker)
- Mandrel
- Fixturing for readout end for curing
- Side cutters for the rough cut
- Fly cutter for new connector (could be MINOS machines which are in hand)
- Optical continuity test station (flash and look for light coming back)
- Pressure leak tester (assume it's just bottled air, gauge, snoop???)
- Module shipping containers and packaging
- Screw guns and screws for the containers

Factory Labor

- Assume a crew of
  - 1 supervisor (assume 50% working on module assembly
  - 3 technicians
- Assume 8h gives 7h of productive work
  - Gives 24.5 FTE-h/shift giving a through put of 12 modules/shift
  - 2 shifts can make a plane per day and keep up well ahead of installation (more later)

Detector site steps

Stack/Assembly outfitting (no readout, liquid in this discussion)

- Receiving/buffering/staging
  - PB delivered by truck from Gaylord, MI
  - Trucks per week (Assume a captive truck)
  - Commercial fixture can remove 50% of load per trip (quote in hand)
  - Uses receiving crane (20t, 100ft span, separate rails)

- Modules delivered by truck from factories
  - Use same fixture/crane
  - Trucks per week (assume a captive truck)

- Steady stream of readout components

- Oil delivered by employee-driver
  - From siding about 20 mi from lab
  - Use leased truck/trailer

- PB/modules staged to stack assembly station by receiving crane/fixtures by shift
- Receiving bridge crane (20t, 120ft span)

- Unloading fixture => Unload truck in 2 lifts (quotes in hand)

- Parts moved from staging to assembly jig via vacuum fixtures on gantry cranes
  - Two of each of these
  - 2t crane, 50ft span, speed spec, separate rails)
  - Commercial vacuum fixture like MINOS, but 50ft and with higher cap pump

- Glue applied by 8-head industrial applicator (quote in had for specs)
  - Polyurethane glue meets draft specs – needs to be tested
  - Two of these

- Screw each layer of PD to fixture it for curing
  - Use fancy screw guns

- Module placed in stack as wood laid
  - Side tabs (replaced “pi clips” in liquid scintillator design)

- Completed stacks moved to erection fixtures by fixture with main bridge
  - Main bridge 100ft span, 25t, variable speed travel

  - Lifting fixture for horizontal planes is rotating vacuum fixture (quote/design in hand)

- Lifting fixture for vertical planes is a strongback (like MINOS, quote in hand)

- 2 man 50ft reach lifts for running the screws into the stack
- Vulcan survey system from MINOS
- Glue barrel handling equipment
- Side face access cages (al a RPC design/MACRO)
- Top catwalk /rail for on top of the detector (6 sets the entire length of the detector installed as plane installed in, say 6ft sections)
- Under-detector support lattice

Hall spaces

Detector is 120 x 600 x 75
Stack space is 120 x 60 x 24
Dock space is 60 x 30 x 24
Storage space is 60 x 60 x 24
Office/lunch/shop… 60 x 30 x 24

Liquid buffering and handling room (see Bower) is either anteroom or more low space

FTEs

	Manpower
Stack Builders	16
Receiving Team	2
Stack Installers	8
Scintillator Movers/Trucking	6
QA/Cablers	4
Support Staff	8
Total FTE's	41

} Same people do both jobs

Installation through put

- 22 pieces to pick per stack
    - 8 big (24x8)
    - 8 short (12x8)
    - 4 thin (12x4)
    - 2 modules
- 12 stacks in a plane => 264 picks / pln
    - At 5 minutes / pick => 22 hr / pln / station
- Parameters
    - 8.5 productive hours in 10 hr day
    - 2 workstations and 2 shifts give 136 workstation hr/wk
    - 6.2 planes per week (PPW) => 6.0 PPW
    - 32 mo @ full rate
- Stretch start by 2.5mo after BO + 2mo for ramp down
    - 36 mo after BO